Transactions of the VŠB - Technical university of Ostrava Vol. VII, No. 2, 2012
Safety Engineering Series p. 49 - 52, DOI 10.2478/v10281-012-0009-6

BAM TTS - A LARGE INFRASTRUCTURE FOR INDUSTRIAL SAFETY TESTING

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Review article

Abstract: An overview is provided of the facilities on the BAM Test site Technical Safety. Large scale experiments - fire, explosion, drop test, which cannot be performed in densely populated urban areas or laboratories. The fin-dings are essential for the assurance and improvement of industrial safety.

Key words: Acetylene, Civil engineering, Drop testing, Dust, Explosion, Fire testing, Industrial safety, Oxygen, Wood preservative.

Introduction

Nano is a buzz word in current research. Industrial safety is addressing nanotechnology, but it also addresses established technologies. They require an infrastructure for large scale testing. The necessity for large scale testing originates in the production facilities and the use of dangerous substances. These may be fuels, chemicals for industrial processes, explosives for mining and demolition. It is also associated with the transport and storage of dangerous substances and the fire behavior of constructions as well as the scale of potential damage to large structures.

Fig. 1 Aerial view of part of BAM Test site Technical Safety

BAM the German Federal Institute for Materials Research and Testing under its guideline Safety in Technology and Chemistry provides an infrastructure for large scale testing in its laboratories in Berlin and in particular on the BAM Test site Technical Safety (BAM TTS) located in Baruth-Horstwalde some 50km south of Berlin. The area of 12 km^2, mainly covered by forests, had been used as military technical training ground from 1871 till 1990 when it was demilitarized and transferred to BAM. Since then BAM has invested more than 25 million Euro to establish a unique testing facility for large scale testing. These facilities are designed such that safety experiments can be performed on an industrial scale.

Materials and methods

BAM TTS comprises seven sections for specialized investigations and a convention center. The sections are

- Fire and explosion test field,
- Drop test facility,
- Blasting area,
- Pendulum impact tester,
- Test field for non-destructive testing in civil engineering,
- Test bed for wood preservatives,
- Test facility for vehicle and vehicle components.

While the last section is let to a private association (Förderverein der Verkehrsversuchsanlage Horstwalde e.V.) the other sections are operated by BAM and will be described in the following chapters.

Fire and explosion test field

Safety parameters of chemical substances and their reactivity are investigated in adjustable containers and pipe systems. Protective components, fittings and construction materials are characterized. Outstanding test facilities are the oxygen test facility, the acetylene decomposition test stand, detonation tube, and the silo for dust explosion testing.

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Oxygen test facility

Oxygen is a very reactive gas and constitutes especially when enriched beyond the atmospheric conditions or pressurized an increased risk, as combustion velocity and burning temperatures are increased while the ignition temperature of non metallic materials is reduced.

Fig. 2 Oxygen test facility

This facility operates at oxygen pressures up to 750 bar. It is equipped with 70 m piping with inner diameters of 12.5 mm, 25 mm and 50 mm where tests with a maximum velocity of 100 $m.s^{-1}$ at a pressure of up to 300 bar can be performed. For open air tests there is a concrete slab of 20 m x 10 m in size.

Acetylene decomposition test stand

Acetylene is most commonly used in organic synthesis. Particular attention, however, is given to the safety of acetylene cylinders and acetylene use for autogenous welding and cutting.

Fig. 3 Autoclave for acetylene testing

The autoclave for acetylene testing is part of a major indoor facility comprising high pressure pipes (1500 bar) with diameters ranging from 10 mm to 50 mm and an open air test stand for detonating acetylene flasks.

Detonation tube

Pipes for the transport of explosive substances from the chemical industry must be designed to withstand explosions or to only explode in predetermined positions. The detonation tube has a diameter of 200 mm and a total length of 30 m. It is segmented to adjust for various investigations. It operates at a nominal pressure of 40 bar. A high pressure device, suitable for up to 1000 bar, is in preparation.

Silo for dust explosion testing

Dust explosions are a pertinent risk in agricultural industries (grain processing, saw mills) and in the chemical industry. BAM investigates dust explosions with respect to numeric modeling under the particular influence of turbulences in silos. The silo can also be used to investigate safety devices such as flame arrestors and fittings.

Fig. 4 Dust explosion in a test silo

The silo consists of several cylindric parts allowing investigations with varied volumes of dust and gas mixtures. Upon establishing stable or dynamic conditions the dust is ignited. Pressure relief is achieved through vertical and horizontal openings in the top section.

Fire test stands

A test field with two fire test stands and infrastructure enables research and testing of the internal and external thermal load bearing capacity of containment systems for dangerous goods. Both test stands have a shielded test area of 12 m x 8 m. One test stand is designed for non-destructive testing of objects with masses of up to 200 tons. The other test stand is suited for destructive tests of objects with up to 20 tons. The caloric input is adjustable.

Fig. 5 Fire testing of a 2700 l tank

Drop test facilities

Transport regulations for dangerous goods require extensive testing of transport containers. This mechanical and thermal testing and extends to numerical modeling. At BAM TTS three major drop test facilities are available: the large drop test facility and two test stands for drops of 1000 kg objects from 12 m height fit for tests according to nuclear safety and explosion safety regulations. In this context it may be referred to the pendulum impact tester.

Large drop test facility

Since BAM is Germany's competent authority for mechanical and thermal type testing of transport containers for radioactive material a large drop test facility was set up that enables real size container testing as well as research beyond the current requirements. The research leads to the quantitative assessment of safety margins. A more detailed overview of the test methods and research performed for the safety of dangerous goods containments is provided on the BAM homepage.

The large drop test facility is a 36 m tower over a closed test hall. The hoist's load capacity of 200 tons corresponds to the largest mass of real transport containers. The overall mass of the base as the unyielding target is 2630 tons with an impact area of 14 m x 14 m x 5 m. The hook clearance is 30 m and thus much higher than the height of 9 m demanded for drop tests in the regulations for the approval of containers.

Fig. 6 Large drop test facility

Pendulum impact tester

Tanks for road and rail transport of dangerous goods must sustain internal and external pressures while for the internal pressure.

Blasting area

The blasting area is a central part of BAM TTS for chemical safety engineering research. Apart from its dimensions of 400 m in diameter surrounded by an earth bund there is a number of dedicated facilities that allow the performance of fire and explosion tests which ensure safe handling of explosives, pyrotechnical articles and chemicals in the gaseous, liquid or solid state. A unique test was the investigation and explosion of a tank wagon tested in fire. Documentation is available on the BAM website.

Not only dangerous goods can be investigated. Fire test of road vehicles and busses have been performed to assess protective systems, safety margins and composition of smoke, and develop appropriate measurement techniques. The results are introduced into numerical modeling.

Regularly expert groups meet at BAM TTS to exchange their views on industrial safety and current achievements in safe handling, transport and storage of dangerous goods.

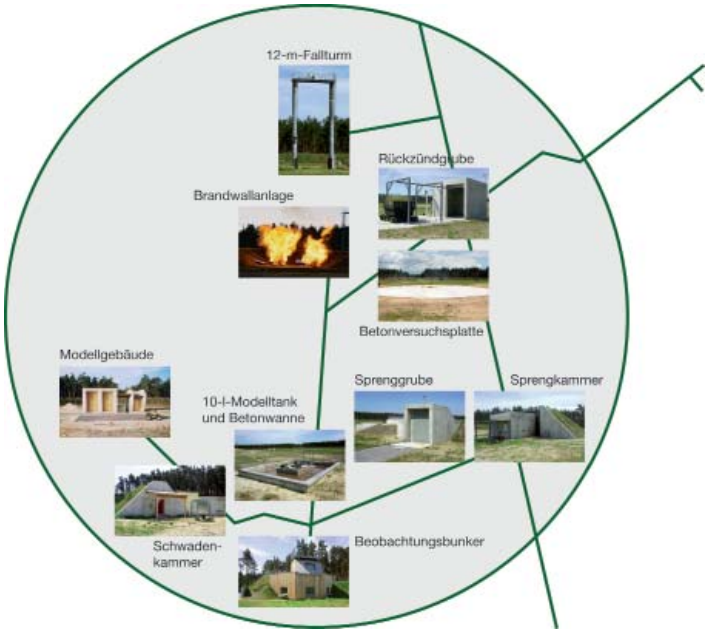

Fig. 7 Test facilities on the blasting area

The test facilities on the blasting area are:

- 12-m-Fallturm - 12m drop tower,
- Rückzündgrube - Ignition pit,
- Brandwallanlage - Fire wall facility,
- Modellgebäude - Model building,
- Schwadenkammer - Fume chamber,
- 10-l-Modelltank - 10 litre model tank and concrete basin,
- Sprenggrube - Explosion pit,
- Sprengkammer - Explosion chamber,
- Beobachtungsbunker - Observation bunker.

Test field for non-destructive testing in civil engineering

Non-destructive testing has been a major research area of BAM for many decades. New testing methodologies are developed. For the non-destructive damage assessment and environmental measurement methods a test field has been set at BAM TTS. It includes ten bored piles, some of them with artificial defects. Other objects are a foundation slab, concrete railway track system and bridge elements. They are well documented and allow the investigation and further development of methods of non-destructive testing in civil engineering.

Test bed for wood preservatives

Due to its history as a technical test site the area of BAM TTS is kept in good natural condition without fertilizers or industrial/ military contamination. This makes the test site well suited for determining the efficacy assessment of wood preservatives in a natural environment in comparison with laboratory results. The preservatives are tested in ground contact (loamy sand soil) and in air. The transfer of preservatives into the soil and its concentration can equally be determined.

Results and Conclusion

The BAM Test site Technical Safety disposes of a large variety of rare or even unique instrumentation and facilities. The test site is used for research and certification. Its facilities can be used in collaborative projects with BAM staff.

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